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### IHO S-100: The New Hydrographic Geospatial Standard for Marine Data and Information

Robert Ward

*International Hydrographic Bureau*

Lee Alexander

*University of New Hampshire, Durham, lee.alexander@unh.edu*

Barrie Greenslade

*United Kingdom Hydrographic Office*

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## NEW STANDARDS FOR PROVIDING METEOROLOGICAL AND HYDROGRAPHIC INFORMATION VIA AIS APPLICATION-SPECIFIC MESSAGES

By Lee Alexander and Kurt Schwehr (USA)  
Center for Coastal and Ocean Mapping/Joint Hydrographic Center  
University of New Hampshire  
Durham, New Hampshire, USA



### Abstract

AIS Application-specific messages transmitted in binary format will be increasingly used to digitally communicate maritime safety/security information between participating vessels and shore stations. This includes time-sensitive meteorological and hydrographic information that is critical for safe vessel transits and efficient ports/waterways management. IMO recently completed a new Safety-of-Navigation Circular (SN/Circ.) that includes a number of meteorological and hydrographic message applications and data parameters. In conjunction with the development of a new SN/Circ., IMO will establish an International Application (IA) Register for AIS Application-Specific Messages. IALA plans to establish a similar register for regional applications. While there are no specific standards for the presentation/display of AIS application-specific messages on shipborne or shore-based systems, IMO issued guidance that includes specific mention of conforming to the e-Navigation concept of operation. For both IHO S-57 and S-100-related data dealing with dynamic met/hydro information, it is recommended that IHO uses the same data content fields and parameters that are defined in the new IMO SN/Circ. on AIS Application-specific Messages



### Résumé

Les messages spécifiques d'application AIS transmis en format binaire seront utilisés de plus en plus pour communiquer par voie numérique les informations relatives à la sûreté/sécurité maritime entre les bâtiments participants et les stations à terre. Ceci inclut les informations météorologiques et hydrographiques qui requièrent un minutage très précis et qui sont cruciales pour le passage en toute sécurité des navires et la gestion efficace des ports et des voies navigables. L'OMI a récemment terminé une nouvelle circulaire du sous-comité sur la sécurité de la navigation (SN/Circ.) qui comprend un certain nombre d'applications pour les messages météorologique et hydrographiques et de paramètres de données. En conjonction avec l'élaboration d'une nouvelle SN/Circ., l'OMI établira un registre d'applications internationales (IA) pour les messages spécifiques d'application AIS. L'AIMS a prévu d'établir un registre similaire pour les applications régionales. Bien qu'il n'existe pas de normes spécifiques pour la présentation des messages spécifiques d'application AIS sur les systèmes embarqués ou basés à terre, l'OMI publie des recommandations qui comportent une mention spécifique de conformité au concept d'opération pour la navigation électronique. En ce qui concerne la S-57 de l'OHI et les données relatives à la S-100 qui portent sur les informations dynamiques météorologiques et hydrographiques, il est recommandé que l'OHI utilise les mêmes champs de contenu de données et les paramètres qui sont définis dans la nouvelle circulaire SN/Circ. sur les messages spécifiques d'application AIS.



## Resumen

Se utilizarán cada vez más los mensajes específicos de la aplicación del Sistema de Identificación Automática (AIS) transmitidos en formato binario para comunicar digitalmente la información sobre la seguridad marítima entre los buques participantes y las estaciones en tierra. Esto incluye la información meteorológica e hidrográfica sensible al tiempo, que es crítica para los tránsitos seguros de buques y para una administración eficaz de puertos/ vías navegables. La OMI ha completado recientemente una nueva Circular del Subcomité sobre la Seguridad de la Navegación (SN/Circ.), que incluye un cierto número de aplicaciones meteorológicas e hidrográficas y de parámetros de datos. Al mismo tiempo que el desarrollo de una nueva SN/Circ., la OMI establecerá un Registro de Aplicaciones Internacionales (IA) para los mensajes específicos de la Aplicación AIS. La IALA proyecta establecer un registro similar para las aplicaciones regionales. Aunque no hay normas específicas para la presentación/visualización de mensajes específicos de la aplicación AIS en los sistemas embarcados o basados en la costa, la OMI publica unas directivas que incluyen una mención específica de conformidad con el concepto de operación para la navegación electrónica. En lo que se refiere a los datos asociados a la S-57 y a la S-100 de la OHI, que tratan sobre información dinámica meteorológica e hidrográfica, se recomienda que la OHI utilice los mismos campos del contenido de datos y los parámetros que están definidos en la nueva SN/Circ. de la OMI sobre los Mensajes Específicos de Aplicación AIS.

## Introduction

Automatic Identification System (AIS) is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. AIS operates in the VHF maritime mobile band using Time Division Multiple Access (TDMA) technology. Chapter V of the 1974 SOLAS Convention [1] required mandatory carriage of AIS equipment for all types and sizes of SOLAS Convention vessels by 31 December 2004. As defined in the IMO Performance Standards for AIS [2], AIS enables both ships and maritime safety administrations to effectively track the movement of vessels in coastal waters. In addition, AIS can contribute to safety-of-navigation and protection of the environment by providing additional navigation-related information in the form of AIS binary messages. This includes meteorological and hydrographic data, carriage of dangerous cargoes, safety and security zones, status of aids-to-navigation, and other ports/waterway safety information. This information is broadcast from shore-side AIS Base Stations or specially equipped buoys to ships that are at-sea or in port.

## AIS Application-Specific Messages

ITU-R Recommendation M.1371-1 [3] (“Technical characteristics for a universal shipborne automatic identification system using time-division multiple access (TDMA) in the VHF maritime mobile band”) provides the basis for the use of AIS binary messages. These messages contain application-specific binary data which can be created by an application on the transmitting side and interpreted and displayed by another application on the receiving end. Proper interpretation depends on the use of an agreed data structure. This means that internationally-agreed binary message (now referred to as “AIS Application-Specific Messages”) standards are essential.

## Current Standards

In May 2004, IMO issued SN/Circ.236 on “Guidance on the Application of AIS binary Messages” [4]. SN/Circ.236 defines the data content for seven (7) types of AIS Binary Message Applications. These were to be tested and evaluated in conjunction with existing shipborne navigation systems during a trial period lasting four (4) years. This included the AIS Minimum Keyboard Display (MKD), radar, ECDIS, and Integrated Navigation System (INS) equipment, as well as Electronic Charting Systems (ECS) and Portable Piloting Units (PPUs). While it is IMO that defines the content of AIS Messages, it is ITU-R M.1371 that specifies the technical characteristic and the structure of the binary AIS messages [3]. The ITU-R Recommendation M.1371-3 provides the basis for the use of AIS binary

messages. These messages contain application-specific binary data which can be created by an application on the transmitting side and interpreted and displayed by another application on the receiving end.

## Revised/New Standards

### International Applications

In July 2008, IMO established a Correspondence Group (CG) to revise the “Guidance on the Application of AIS Binary Messages” contained in SN/Circ.236. The CG included representatives from 14 IMO Member Governments, a UN specialized agency (WMO), and several intergovernmental organizations – including IHO. In developing international application specific messages, several criteria pertained:

- The messages should provide information that enhances safety of life at sea, efficiency of navigation, and protection of the marine environment.
- The use of the message should result in operational benefits.
- The information should be effectively displayed by an appropriate user interface.
- Messages should not be used for information that is available from other sources with sufficient time in advance, or used for private or profitable purpose.

In April 2009, the CG submitted a report to IMO that included both revised and new messages [5]. In July 2009, IMO NAV 55 agreed to issue a new SN/Circular on “Guidance on the Use of AIS Application-Specific Messages” [6]. Some existing messages in SN/Circ.236 were revised while others were replaced by new messages with enhanced functionality. In addition, some messages with similar functionality were harmonized and merged into a new message. Following formal approval by the Maritime Safety Committee (MSC87) in May 2010, this new circular would supersede SN/Circ.236 beginning 1 January 2013.

*Table 1:* provides a comparison of existing applications contained in SN/Circ.236 and the revised/new messages in the new SN/Circ. AIS Application-Specific messages that pertain to meteorological/hydrographic information are high-lighted in blue.

The following is a brief description of those message applications that are directly related to meteorological and hydrographic parameters.

- Meteorological and Hydrographic Data – This message provides a wide variety of meteorological and hydrographic data including, wind speed/direction, visibility, tide/water levels, surface currents, wave and swell measurements, sea state, and ice. Initially developed by IALA, it is currently in wide use. Other than changing the name from Hydrological to Hydrographic, the information content in SN/Circ.236 is unchanged.

SN/Circ.236			“new” SN/Circ.	
Appl No.	Message Name	FI	Message Name	FI
1	Met/Hydrological	11	Met/Hydrographic	11
2	Dangerous cargo indication	12	Dangerous cargo indication	25
3	Fairway closed	13	---	--
4	Tidal window	14	Tidal window	14
5	Extended ship static and voyage related data	15	Extended ship static and voyage related data	24
6	No. of persons onboard	16	No. of persons onboard	16
7	Pseudo-AIS targets	17	VTS-generated targets	17
			Clearance time to enter port	18
			Marine traffic signal	19
			Berthing data	20
			Weather report from ships	21
			Area Notice - broadcast	22
			Area Notice - addressed	23
			Environmental	26
			Route Information – broadcast	27
			Route Information – addressed	28
			Text Description – broadcast	29
			Text Description – addressed	30

*Table 1 Comparison of existing AIS Application-Specific Messages contained in IMO SN/Circ.236 and the revised/new messages contained in the “new” SN/Circ.*

- **Tidal Window** – This message is used to inform vessels about tidal windows which allow a vessel safe passage in a fairway or channel. In addition to date/time and location, information is also provided on current direction and speed. Similar to the Met/Hydro, this message is already in use. As such, the information content in SN/Circ.236 is unchanged.
- **Weather Report from Ship to Other Ships** – Developed by the World Meteorological Organization (WMO), this message is intended to provide weather information observed on a ship in transit to other vessels, or to WMO. This includes present weather conditions related to visibility, wind, temperature, wave height and swell period/direction.
- **Environmental** – Proposed by the USA/RTCM, this message has a flexible design and is well-suited for some applications, while the Met/Hydro message in SN/Circ.236 is more suited for other situations. Since transmission of Met/Hydro information via binary messages is increasingly used, two different message types are available depending on the particular situation.

The Met/Hydro message is best suited for local transmission of information from several sensors at the same position. Alternatively, the Environmental message separates static data (e.g., station ID, location) from dynamic sensor data. In some situations, it is possible to send same data content using fewer slots than the Met/Hydro message.

This is particularly useful when broadcasting both forecast and “Nowcast” (i.e. continuously updated forecast) information.

Detailed parameters and descriptions for these AIS Application-Specific Messages are contained in the various tables of the “new” IMO SN/Circ.

#### Table Application

- 1.1 Meteorological and hydrographic Data
- 3.1 Tidal window
- 10.1 Weather observation report – from ship to other ships
- 12.1 Environmental
  - .2 Environmental message sensor report framework
  - .3 Environmental message sensor report types
  - .4 Sensor site location
  - .5 Station ID
  - .6 Wind report
  - .7 Water level report
  - .8 Current flow report: two-dimensions (x & y)
  - .9 Current flow report: 3-dimensions (x, y, & z)
  - .10 Horizontal current flow report
  - .11 Sea-state report
  - .12 Salinity report
  - .13 Weather report
  - .14 Air gap

The complete IMO SN/Circ. can be downloaded from the IMO website [<http://www.imo.org>], under the NAV55 documents.

However, this website is accessible only to IMO Member States and Authorized Organizations.<sup>1</sup>

### Regional Applications

In addition to the new IMO standard, the Radio Technical Commission for Maritime Services (RTCM) is developing a standard that defines the scope and content of AIS Application-Specific messages that are intended for both international and regional use. For international use, the RTCM standard provides further guidance/refinement on the use of AIS binary messages that have been published or are planned to be issued by the International Maritime Organization (IMO). This includes both IMO SN/Circ.236 and the new SN/Circ. to be issued in 2010. Applications intended for regional use include those that were developed for use in North America and other regions. In particular, the RTCM standard contains a “Waterways Management” application that is not contained in either the IMO SN/Circ.236 or the new SN/Circ.

Currently, the Draft *RTCM Standard [I21xx.1] for AIS Binary Application-specific Messages: International and Regional Use* is in the final stages of refinement, and will likely be approved at the 2010 RTCM Annual Assembly meeting in May 2010. It is not the intent of RTCM to duplicate the IMO standard. Instead, there is benefit in publishing the content of these messages in order to begin the implementation process. Further, some of the messages contained in the new SN/Circ. have not been adequately field-tested, and may require further refinement or clarification in order to be properly used. Finally, since it is not likely that the new IMO SN/Circ. would be revised for 4-5 years after it is issued, the RTCM standard serves as a means to address any errors that need to be corrected, or deficiencies that should be resolved. This will be performed by issuing an updated version of RTCM standard on a periodic basis (e.g., once a year).

### **Registers**

#### International

In conjunction with the development of a new SN/Circ., IMO NAV 55 agreed to establish an International Application (IA) Register for AIS Application-Specific Messages. Similar to the IHO Geospatial Information Infrastructure Registry [7], the IMO AIS Application Specific Register will be organized and managed based on guidance contained in *ISO Standard 19135*.

<sup>1</sup>A working copy of the revised SN/Circ. (NAV55/21/Add.1) that was issued by IMO on 22 October 2009 is available at: [<http://vislab-com.unh.edu/~schwahr/papers/2009-Nav55-CG-AIX-Report-Annex1.pdf>].

Establishing the necessary operational management and oversight should benefit all those who create, broadcast, and use AIS Binary Messages. This includes:

- 1) Establishing specific procedures regarding proper submission of proposals, reviewing/accepting proposals, and access to the database.
- 2) Defining the roles and responsibilities of the Register Owner, Register Manager, Control Body, Submitting Organizations, and Proposers.

#### Regional

At the 1<sup>st</sup> Meeting of the IALA e-Navigation Committee (eNAV1) in 2007, it was agreed that IALA would maintain a register of regional applications for AIS Application-Specific Messages. The intent is to provide information to all interested parties of what currently exists and/or is in use. In this way, IALA Members and other National Aids-to-Navigation Authorities can make use of existing applications, and avoid developing new messages with only minor/marginal differences. It also provides a site where it can be determined what countries are using the same regional message.

At IALA eNAV6, it was agreed that establishing the Register should be a two-phase process:

- 1<sup>st</sup> - Compile all existing AIS binaries into a “collection” (i.e., a compilation or catalogue).
- 2<sup>nd</sup> - Convert the “collection” into a Register.

Once completed, IALA would then develop guidance on best practices for creating and using AIS Application Specific Messages [8].

If IMO and IALA undertake a similar approach toward registers, *Table 2* provides a comparison of the likely organizational structures.

### **Displaying AIS Application-specific Messages**

Currently, SOLAS vessels are not required to have specific equipment capable of interpreting, processing or displaying the information content of AIS application specific messages. While the Minimum Keyboard Display (MKD) is capable of displaying text messages, it was never intended for the graphical display/presentation of AIS Application-specific messages. However, some AIS binary messages are already being displayed on other shipborne equipment including radar, ECDIS, INS, and PPUs.

At a minimum, there are four basic display options: alpha-numeric, graphical, symbol, and geo-spatial. *Table 3* indicates which options have been used for the existing/revised applications contained in SN/Circ.236.

	International	Regional
Register Owner	<b>IMO</b>	<b>IALA</b>
Register Manager	Maritime Safety Division	e-Navigation Committee
Control Body	Sub-Comm. on Safety of Nav (NAV)	AIS Technical WG
Submitting Organizations	IMO Member Governments UN specialized agencies Inter-governmental organizations NGIOS	IALA Member Administrations [others?]

*Table 2 – Comparison of the proposed organizational structures for the International and regional registers for AIS Application-Specific Messages.*

#	Application	Alpha-numeric	Graphical	Symbol	Geo-spatial (Point, line, or area)
1	Meteorological and hydrological data	X	X	X	X
2	Dangerous cargo Indication	X			
3	Fairway closed	X			X
4	Tidal window	X	X	X	X
5	Extended ship static and voyage-related data	X	X		
6	Number of persons onboard	X			
7	VTS-generated AIS targets			X	X

*Table 3 – Basic options for displaying the AIS application-specific messages contained in IMO SN/*

#### Current Standards

At present, there is no specific guidance or standards related to the presentation/display of AIS application-specific messages on shipborne equipment or systems. However, there are IMO and IEC standards that provide general “guidance” related to the presentation/display of navigation-related information on shipborne navigational displays.

*Performance Standards for the Presentation of Navigation-related Information on Shipborne Navigational Displays*, IMO resolution **MSC.191(79)**, 6 December 2004.

*Guidelines for the Presentation of Navigation-related Symbols, Terms and Abbreviations*, IMO **SN/Circ.243**, 15 December 2004.

*Presentation of Navigation-related Information on Shipborne Navigational Displays – General Requirements, methods of testing, required test requirements*. **IEC 62288**, Edition 1.0, July 2008.

There are specific equipment/system standards that have been adopted by IMO, IHO, and IEC dealing with to the presentation/display of shipborne navigation-related information.

*Revised Performance Standards for ECDIS*, IMO **MSC.232(82)**, 2006.

*Specifications for Chart Content and Display Aspects of ECDIS*, IHO S-52, Ed. 4.2, Appendix 2, *Colour and Symbol Specifications for ECDIS*, March 2004.

*Performance Standards for Radar Equipment*, IMO **MSC.192(79)**, 2004.

*Performance Standards for an Integrated Navigation System (INS)*, IMO resolution 86(70), Annex 3.

*Integrated Navigation Systems (INS) – Operational and performance requirements, methods of testing and required test results*. IEC 61294, Ed. 1, 2004.

*Performance Standards for a Universal Shipborne Automatic Identification System (AIS)*, IMO resolution **MSC.74(69)**, Annex 3, 19 May 1998.

*Guidelines for the Onboard Operational Use of Shipborne Automatic Identification Systems (AIS)*, IMO resolution **A.917(22)**, 25 January 2002.

*Display of AIS Target Information*, IMO **SN/Circ.217**, 11 July 2001.

*Guidance of the Application of AIS Binary Messages*, IMO **SN/Circ.236**, 28 May 2004.

Many of these standards were adopted prior to resolution **MSC.191(79)**, **SN/Circ.236**, or **IEC 62288** being issued. Eventually, these equipment-specific performance standards will need to be “updated” to make sure that they comply with the overall harmonized requirements contained in resolution **MSC.191(79)**. In the interim, there does not appear to be any existing requirement that would preclude the presentation/display of any of the AIS binary message applications contained in **SN/Circ.236** or the revised/new messages. However, it will not be possible to reach a general consensus about the consistent and uniform display of AIS binary messages until the performance standards for individual shipboard equipment and systems are aligned with resolution **MSC.191(79)**. Also, there is need for more operational testing and experience before any specifications or standards are adopted.

In the interim, IMO NAV55 issued “Guidance for the Presentation and Display of AIS Application Specific Messages Information”. [9].

#### Guiding Principles

It is premature to propose specific presentation/display standards for AIS application-specific Messages. In particular, more experience is needed in order to determine how AIS binary message information should be displayed in conjunction with other chart-related and operational information. However, the “Guidance for the Presentation and Display of AIS Application Specific Messages” stated that the presentation/display of AIS application specific messages should conform to the concept of operation envisioned for e-Navigation [9].

As defined by IMO:

*“e-Navigation is the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment.”*(NAV 54/25, Annex 12) [10].

Further, AIS Application-specific messages should become an effective means to achieve many of the core objectives of e-Navigation:

- .1 facilitate safe and secure navigation of vessels having regard to hydrographic, meteorological and navigational information and risks;
  - .2 facilitate vessel traffic observation and management from shore/coastal facilities, where appropriate;
  - .3 facilitate communications, including data exchange, among ship to ship, ship to shore, shore to ship, shore to shore and other users;
  - .4 provide opportunities for improving the efficiency of transport and logistics;
  - .5 support the effective operation of contingency response, and search and rescue services;
  - .6 demonstrate defined levels of accuracy, integrity and continuity appropriate to a safety-critical system;
  - .7 integrate and present information on board and ashore through a human-machine interface which maximizes navigational safety benefits and minimizes any risks of confusion or misinterpretation on the part of the user;
  - .8 integrate and present information on board and ashore to manage the workload of the users, while also motivating and engaging the user and supporting decision-making;
- (NAV 54/25, Annex 12) [10]

The “Guidance” issued at IMO NAV 55 also included some guiding principles that should apply to the display of AIS application-specific messages both for shipborne equipment/systems (e.g., ECDIS, radar, & INS) and shore-based systems (e.g., VTS Centre console):

1. Use **consistent** symbology across all displays.
2. **Uniqueness** – only one possible meaning.
3. **Non-ambiguous** – ability to determine differences (*i.e.* distinct).
4. **Intuitively obvious** – an easily recognized symbol, icon or pattern.
5. Have a **basic symbol** for different categories. Further attributes should be enhancements (not changes) to the basic symbol. (NAV 55/25, Add.1, Annex 2) [10]

In concept, few would likely disagree with these principles. However, in practice it will be a challenge to achieve a consensus between providers and users as to what is really suitable or effective.

#### **Relationship to IHO Standards**

Since its adoption 1998, IHO S-57 Edition 3.0/3.1 has been used almost exclusively for encoding Electronic Navigational Charts (ENCs) for use in Electronic Chart Display and Information Systems (ECDIS) [11]. More recently, Marine Information Overlays (MIOs) in S-57 format have been developed for both static and dynamic parameters [12].

The new IHO Geospatial Standard for Digital Hydrographic Data (S-100) [7] is intended to be used for the exchange of digital hydrographic data between hydrographic offices, and for the distribution of hydrographic data to manufacturers, mariners and other data users (e.g., environmental management organizations). It was developed so that the transfer of all forms of hydrographic data would take place in a consistent and uniform manner. As announced by IHO, an S-101 ENC Product Specification is under development and will go into force in 2012.

AIS application-specific messages are already in use, and this will likely increase. Ideally, AIS binary Messages and IHO S-100 will be compatible in terms of complementary data content and format such that both can be used in ECDIS, INS, and PPU. For both IHO S-57 and S-100-related data dealing with dynamic met/hydro information, it is recommended that the hydrographic community use the same data content fields and parameters that are defined in the new IMO SN/Circ. on AIS Application Specific messages.



## Looking Ahead

The challenges associated with the use of AIS-Application Specific Messages are more organizational than technical. Based on what has occurred in the past, it may be a difficult and time-consuming process to establish the necessary infrastructure for one government agency to convert met/hydro sensor data into a binary format, and then pass it to another agency to be broadcast via AIS base stations as AIS application-specific messages. Often times, different agencies have different ideas on what types of met/hydro data are important, and the level of detail that is required. While most would agree on the need to provide met/hydro data, agreeing on the specific details regarding data parameters, formatting, and distribution can be problematic. To accomplish the process will require a fair amount of cooperation between intra- and inter-government agencies, equipment manufacturers, and maritime user groups. While these organizational challenges may be difficult to overcome, significant benefits result when "harmonized" regional and/or international standards are implemented and used by all concerned.

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## Biographies of the Authors

**Dr. Lee Alexander** is a Research Associate Professor at the Center for Coastal and Ocean Mapping at the University of New Hampshire, and an Adjunct Professor at the University of New Brunswick. Previously a Research Scientist with the US Coast Guard and a Visiting Scientist to the Canadian Hydrographic Service, he serves on a number of international committees and working groups dealing with electronic charting, shipboard navigation system, and e-Navigation standards. He has published over 100 papers and reports on electronic chart-related technologies, and is a co-author of a textbook on Electronic Charting.

**Dr. Kurt Schwehr** is a Research Assistant Professor at the Center for Coastal and Ocean Mapping (CCOM) at the University of New Hampshire. In addition to AIS broadcast applications, he works on a range of projects including developing Chart-of-the-Future technologies, visualization techniques for underwater and space applications, and understanding marine sedimentary processes. He received his PhD from Scripps Institution of Oceanography in marine geology/geophysics, and received a B.S. from Stanford University. Before joining CCOM he worked at the Jet Propulsion Lab, NASA Ames, the Field Robotics Center at Carnegie Mellon, and the US Geological Survey Menlo Park.